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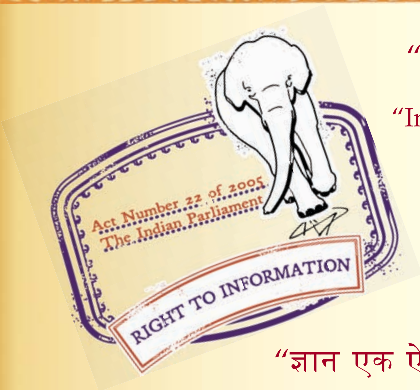


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IS : 8455 - 1977
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# *Indian Standard*

# RECOMMENDED PROCEDURE FOR WELDING OF POLYETHYLENE

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# *Indian Standard*

# RECOMMENDED PROCEDURE FOR WELDING OF POLYETHYLENE

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# *Indian Standard*

## RECOMMENDED PROCEDURE FOR WELDING OF POLYETHYLENE

## 0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 29 April 1977, after the draft finalized by the Welding General Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 In recent years considerable progress has been made in the application of welding in the plastic industry. This standard has been prepared as a guide to the industry in welding of polyethylene.

0.3 In the preparation of this standard assistance has been derived from DIN 16932 ' Welding of PE (polyethylene ): Directions ', issued by DIN Deutsches Institut für Normung.

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## 1. SCOPE

1.1 This standard is intended to serve as a guide for welding of polyethylene.

## 2. GENERAL

2.1 In view of the availability of a large variety of types of polyethylene ( abbreviated as PE ) which differ in mechanical properties and particularly in their density and melting characteristics, the welding process and procedure differ from material to material. Therefore, welding should be resorted to only for joining parts of same type of PE.

2.2 Polyethylene is welded in a plastic condition. The influencing factors are the welding temperature, direction and amount of heat impact and the welding pressure. The welding conditions are dependent on the behaviour of the PE type to be welded. In the absence of any data the welding procedure should be established in each case by conducting procedural tests.

2.3 Polyethylene should not be welded at temperatures below the crystallite melting temperature and above the degradation temperature to avoid defects in the welded joint. The crystallite melting points for different densities are given in Fig. 1.

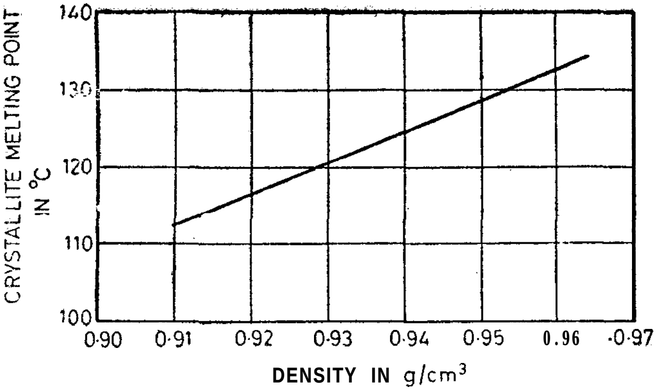



FIG. 1 CRYSTALLITE MELTING POINTS FOR POLYETHYLENE

## 3. HOT GAS WELDING

**3.1** In this process the contact surfaces of parts to be welded and the filler material are heated to the desired temperature using hot gases and the parts welded under pressure.

**3.2 Welding Equipment** — Manual welding torches are normally used in which gas free from oil and moisture and at a pressure of 0·05 MPa (0·5 $kgf/cm^2$) is heated to the required temperature. Examples of welding torches normally used are given in Fig. 2 and 3. In practice air is chiefly used as the welding gas for PE. The temperature of the gas should be adjustable. The temperature is measured at 5 mm from the end of the nozzle of the welding torch.

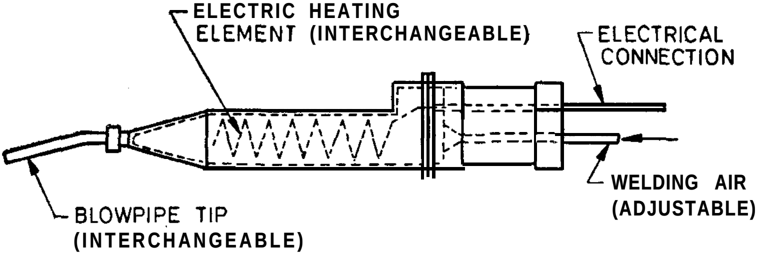



FIG. 2 ELECTRICALLY-HEATED HOT GAS WELDING EQUIPMENT

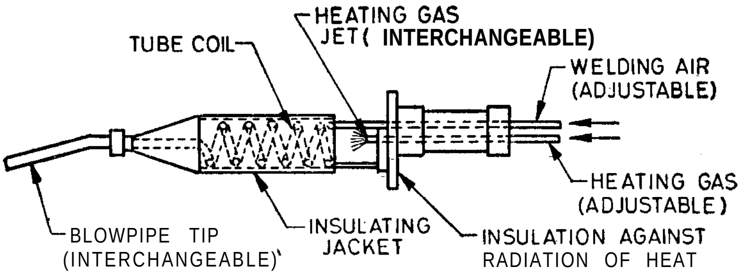



FIG. 3 GAS-HEATED HOT GAS WELDING EQUIPMENT

**3.3 Filler Material** — The filler material used for welding PE should be of the same type as PE being welded. It is, therefore, preferable to use the filler material cut from the base material being welded. The filler material may also be extruded from the basic raw material from which the parent material being welded is manufactured.

3.3.1 Filler rods used are normally of 3 or 4 mm diameter and are finished to required profiles ( for example, triangular shape for welding V-welds ), although circular cross section is preferred.

3.3.2 Where circular rods are employed, 3 mm diameter rods are used for root and sealing runs ( dimension $d_1$ in Fig. 4 to 10 ). For subsequent runs and finishing runs and where thickness does not exceed 5 mm, 3 mm filler rods shall be used. Where thickness to be welded exceeds 5 mm the filler material used for subsequent and finishing runs shall be of 4 mm diameter ( dimension $d_2$ in Fig. 4 to 10 ).

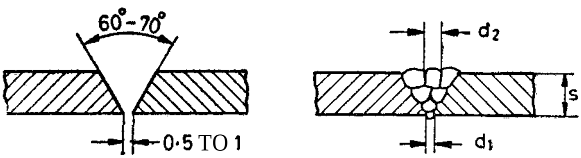
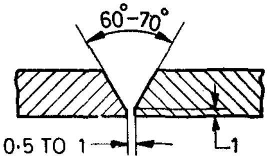
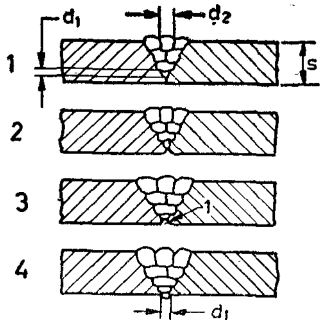



FIG. 4 SINGLE V-BUTT WELD WITHOUT SEALING RUN

**3.4 Weld Forms** — Types of joints made by hot gas welding are single V-butt welds without and with sealing run ( see Fig. 4 and 5 ). In the case of joints with sealing run, the root side of the joint is gouged before depositing the sealing run. Where filler rods of triangular shape are employed, no sealing run is required ( see Fig. 6 ).




1. Welding V-Weld
2. Make an angled root
3. Make the *root* round
4. Weld the sealing run

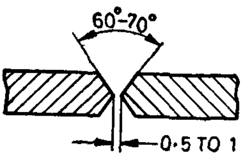
**5A PREPARATION OF THE V-BUTT WELD**

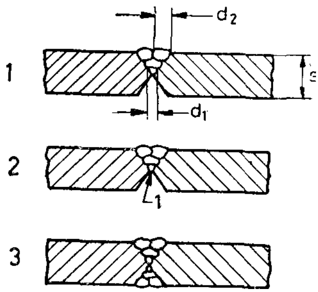
**5B WELDING THE V-BUTT WELD**

All dimensions in millimetres.

**FIG. 5** SINGLE V-BUTT WELD WITH SEALING RUN

**FIG. 6 SINGLE V-BUTT WELD MADE WITH TRIANGULAR ROD**



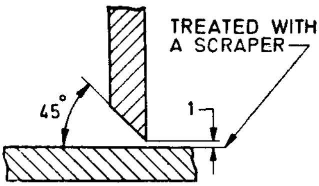

1. Weld one side of the double V-butt weld
2. Make the root round
3. Weld the other side of the V-butt weld

**7A PREPARATION OF THE DOUBLE V-BUTT WELD**

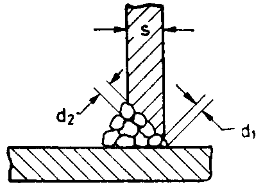
**7B WELDING THE DOUBLE V-BUTT WELD**

All dimensions in millimetres.

**FIG. 7 DOUBLE V-BUTT WELD**



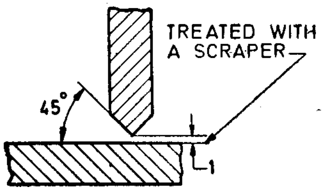

**8A PREPARATION OF THE FILLET WELD**



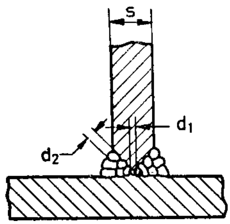

**88 WELDING THE FILLET WELD**

All dimensions in millimetres.

FIG. 8 T-JOINT WITH SINGLE FILLET WELD



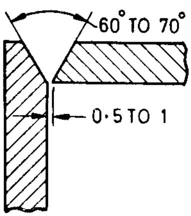

**9A PREPARATION OF THE FILLET WELD**



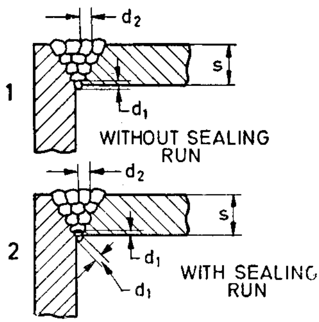

**98 WELDING THE FILLET WELD**

All dimensions in millimetres.

FIG. 9 T-JOINT WITH DOUBLE FILLET WELD




**10A PREPARATION OF THE BUTT WELD**




1. Without sealing run
2. With sealing run

**10B WELDING THE BUTT WELD**

All dimensions in millimetres.

FIG. 10 CORNER JOINT WITH SINGLE V-BUTT WELD

3.4.1 Double V- butt joints are shown in Fig. 7. Weld on one side of the joint is deposited. The root of the joint is gouged before depositing the weld on the other side.

3.4.2 T-joints with fillet welds ( see Fig. 8 and 9 ) and corner joints with butt welds (see Fig. 10 ) should be avoided as far as possible by suitably designing the fabrication procedure. Where these are unavoidable they should be made using heated tool process.

Instead of the corner joint shown in Fig. 10 it is preferable to adopt a joint shown in Fig. 11 using single or double V- butt welds.

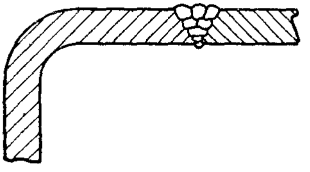


FIG. 11 BETTER SOLUTION THAN THE CORNER JOINT SHOWN IN FIG. 10

3.5 **Preparation of the Parts to be Welded -** The surfaces of poly-ethylene parts stored for a long time may undergo changes due to the actions of ultra-violet radiation or due to dirt accumulation. The portion of the parts affected should be removed by scraping prior to welding unless the joint faces are to be prepared by machining, for example, by planing, rasping, milling or grinding. This provision applies to the filler rods also. The filler rods and the connecting surfaces of the parts should be free from shavings, traces of grease and other impurities.

3.6 **Welding Procedure** — Wherever possible welds shall be made in the flat position. One end of the welding rod is pointed with a knife and fixed to the seam. With continuous and uniform heating of the base material and the filler material, the parts to be welded are raised to the welding temperature with a slight to-and-fro movement of the nozzle of the torch in the direction of welding. As soon as the filler rod becomes plastic, it is pressed into the joint without allowing it to buckle ( holding the filler rod as close as possible to the welding end ).

3.6.1 In order that the material reaches the welding temperature the welding gas should have been heated to a temperature of 200 to 300°C measured 5 mm from the nozzle of the welding torch, depending upon the type of polyethylene being welded. The temperature of the welding gas influences the speed of welding and should, therefore, be assessed for each application. When using high speed welding equipment the temperature should be about 20” higher than the temperature mentioned earlier.

3.6.2 Heating should be such that neither the parent material nor the filler material should reach full plasticity. Once this stage is reached the welding pressure drastically reduces and further welding will not be possible The correct plasticity is indicated from the fact that the filler rod does not spring back when the welder temporarily releases his grip on it, and it pushes in front of it a shiny 'bow wave' which does not contain any bubbles.

3.7 **Weld Finish** — Normally the weld is not machined. If for any reason it has to be finished, machining marks shall be avoided.

3.8 **Quality of Weld** — The following factors influence the quality of the welded joint:

a) Welding conditions — temperature, speed and pressure;
b) Selection of filler material to suit the parent material;
c) Form of weld;
d) Number of runs in the weld seam — a few thick runs are better than several thin ones;
e) Freedom from kinks, etc;
f) Cleanliness of the joining faces and the filler material; and
g) Welder's skill.

3.9 **Strength of Weld** — For purpose of design a joint strength equal to 0·6 times the strength of the parent material may be assumed.

## 4. HEATED TOOL WELDING

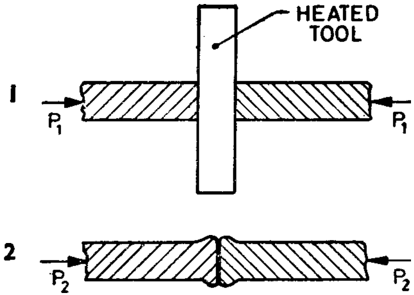
**4.1 Welding Process** — In this process the surfaces to be welded are heated to the required temperature by suitably designed heating tools and welded under pressure, usually without the use of filler material.

4.2 **Welding Equipment**-The heating tools for welding are heated electrically, with gas or other suitable means. They transmit their heat by conduction to the surfaces of the parts to be welded. The heating tool should be free from scales. Residues of YE should be prevented from adhering to the heating tool, and this can be achieved effectively by means of a polytetrafluoro ethylene ( PTFE ) covering.

4.2.1 Heating tool may also be in the form of thin electric wires which may be incorporated in the final joint.

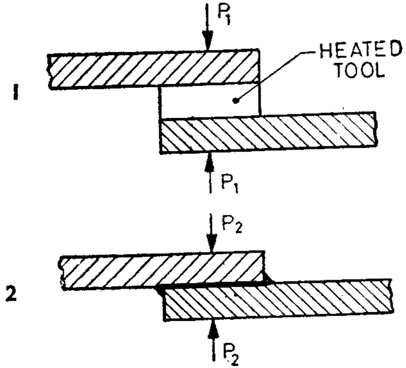
4.3 **Filler Material** — Filler material is generally not used in heated tool welding process.

4.4 **Weld Form** — Butt weld, lap joint with lap weld (welding of overlapped surfaces ), fold welding and T-joint are some of the welds produced in this process. These are illustrated in Fig. 12 to 15.



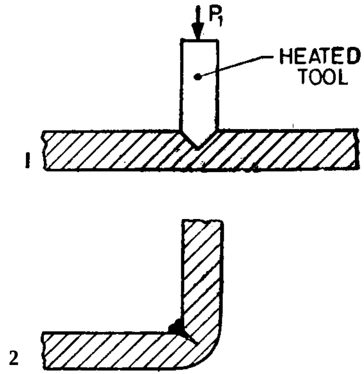

1. Heating
2. Welding

FIG. 12 HEATED TOOL WELDING



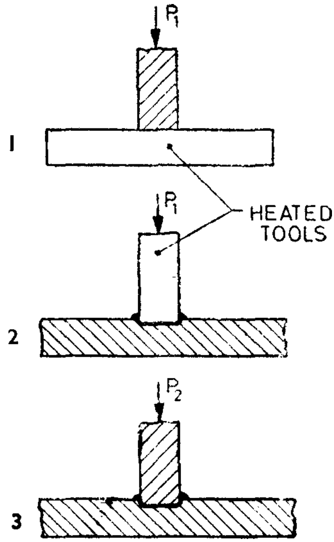

1. Heating
2. Welding

FIG. 13 LAP JOINT WITH LAP WELD




1. Heating
2. Welding

FIG. 14 FOLD WELDING




1. Heating one part
2. At the same time heating other part
3. Welding

FIG. 15 T-JOINT BY BUTT WELDING

4.5 **Preparation of Parts to be Welded** — Where necessary the connecting parts shall be prepared according to 3.5. The connecting surfaces and the heating tool shall be free from shavings, traces of grease and other impurities.

4.6 **Welding Procedure** — The heating tool is brought into contact with the welding surfaces exercising a slight pressure $P_1$ not exceeding 4 MPa. As soon as the parts reach the welding temperature the heating tool is withdrawn and the connecting surfaces are brought into contact together and welded subjecting them to the required pressure.

4.6.1 The temperature of the heated tool should be between 180°C and 200°C depending on the type of PE being welded. At this temperature the PE reaches the thermoplastic range at the points of contact.

4.6.2 The pressure $P_2$ during welding should be such that all the overheated or oxidized material is expelled from the weld zone leaving behind at the same time sufficient plastic material to form a well bonded joint. For best results pressure $P_2$ should not exceed 12 MPa (1·2 kgf/cm²).

**4.7 Weld-Finishing** — The welds do not normally require finishing. If for any reason the weld is to he finished kinks should be avoided.

**4.8 Quality of Welds** — The quality of the finished joint depends on the following factors:

a) Selection of welding conditions -welding temperature, welding pressure and duration of its application, etc;

b) Cleanliness of the connecting surfaces and the heating tool; and

c) Skill of the welder.

4.8.1 If carefully executed it is possible to achieve weld strength equal to that of the parent material.

## 5. IMPULSE WELDING

**5.1 Welding Process** — In this process the parts to be welded are kept one above the other and heated by heat impulses from heating tools in contact with them and welded under pressure.

5.2 **Welding Equipment** — The impulse welding equipment consists of a power supply unit ( power source ), pressure device and impulse plate. The impulse pressure plate has electrical heating elements of extremely low heat capacity which are briefly heated electrically (for example, 0·25 second) after pressing against the weld line. The welding heat is then removed from the weld zone in the same operation maintaining the pressure until the weld zone has regained its dimensional stability. Residues of PE should be prevented from adhering to the heating surfaces of the equipment, an effective means of doing this being a PTFE coating.

5.3 Filler **Material** — In this process filler material is not generally used.

5.4 **Weld Forms -Lap** joints with welds on overlapped surfaces are possible in this process.

5.5 **Preparation of Parts to be Welded** — The surfaces to be welded need no special preparations, but the surfaces and the heated tool should be free from traces of grease and other impurities.

5.6 **Welding Procedure** -The connecting surfaces of the parts to be welded ( films ) are placed on a mounting plate covered with an elastic heat insulator so that they overlap. The impulse pressure plate ( plate with heating element and heat insulator ) is pressed on to the welding line by means of a suitable pressure device and heated electrically for a brief period. The pressure is maintained until the weld zone is cooled off. With films of thickness between 0·15 and about 0·25 mm, the mounting plate is also designed as an impulse pressure plate ( heat impulses on both sides of joint ). With films of thickness greater than 0·25 mm, heated tool welding is preferable to impulse welding.

5.7 **Weld Finish** — The welds made by impulse process need no further finishing.

5.8 **Quality of Weld** — The provisions contained in 4.8 shall apply. For design purpose a strength of 60 to 80 percent of the strength of parent metal may be assumed.

## 6. FRICTION WELDING

6.1 Welding Process — In this process the connecting surfaces of the parts to be welded, usually solids of rotation, are heated to the required welding temperature by frictional heat and welded under pressure without the use of filler material.

6.2 Welding Equipment — The equipment consists of a turning machine such as lathe, which permits turning of the connecting surfaces ( of the parts to be welded ) sufficiently quickly under pressure against each other so that the surfaces are heated to welding temperature by frictional heat.

6.3 **Filler Material** — Filler material is not needed in this process.

6.4 **Weld Form** — Butt joints with welded contact surfaces are possible by friction welding.

6.5 **Preparation of Parts to be Welded** — The connecting surfaces up to 40 mm diameter are faced. When the diameter (d) exceeds 40 mm it is advisable to taper both the connecting surfaces by turning them to a cone of slope $\alpha/2$ where tan $\frac{\alpha}{2} = \frac{d}{2}$.

The connecting surfaces should be free from shavings, traces of grease and other impurities.

6.5.1 Hollow members may be centred by means of inserted plugs or external guides made of such material that cannot be welded to PE.

6.6 Welding Procedure-The parts to be welded are clamped in the turning attachment -of the equipment and turned against each other under pressure. When the surfaces reach the welding temperature — which is apparent when the pasty material oozes out all round the circumference — the axial pressure is increased. The attachments are then clamped and movements of the two parts against each other is concluded. The welding pressure is maintained until the joint has cooled off ( see Fig. 16 ).

NOTE — Depending upon thickness of parts and the type of PE being welded the pressure should be increased slowly. From the annular gap between the parts to be welded a fine powder should first emerge followed by short threads of material until finally the glassy welding bead results.

If the pressure is increased too much the parts do not get welded. Care should be taken that the parts are not heated to melting temperature. Otherwise the welding pressure drastically reduces and no welding takes place.

**6.7 Weld Finish** — The provisions contained in 4.7 apply;

6.8 **Quality of Welded Joint** — In friction welding butt joints of strength equal to that of the parent material are achieved.

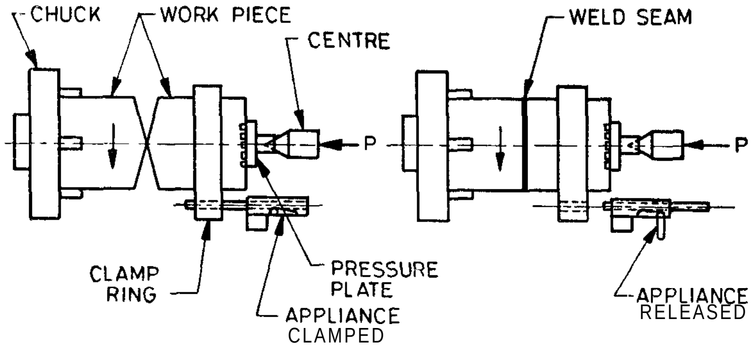



FIG. 16 FRICTION WELDING

## 7. HIGH FREQUENCY WELDING

**7.1** High frequency welding is not. a popular method of welding PE in view of special dielectric properties of PE.

( Continued from page 2 )

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# INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

## Base Units

| *Quantity* | *Unit* | *Symbol* |
|---|---|---|
| Length | metre | m |
| Mass | kilogram | kg |
| Time | second | s |
| Electric current | ampere | A |
| Thermodynamic temperature | kelvin | K |
| Luminous intensity | candela | cd |
| Amount of substance | mole | mol |

## Supplementary Units

| *Quantity* | *Unit* | *Symbol* |
|---|---|---|
| Plane angle | radian | rad |
| Solid angle | steradian | sr |

## Derived Units

| *Quantity* | *Unit* | *Symbol* | *Conversion* |
|---|---|---|---|
| Force | newton | N | 1 N = 1 kg.1 $m/s^2$ |
| Energy | joule | J | 1 J = 1 N.m |
| Power | watt | W | 1 W = 1 J/s |
| Flux | weber | Wb | 1 Wb = 1 V.s |
| Flux density | tesla | T | 1 T = 1 $Wb/m^2$ |
| Frequency | hertz | Hz | 1 Hz = 1 c/s ($s^{-1}$) |
| Electric conductance | siemens | S | 1 S = 1 A/V |
| Pressure, stress | pascal | Pa | 1 Pa = 1 N/m* |